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Effect of IBA and cutting thickness on growth attributes of grape rootstocks (*Vitis vinifera* L.)

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Abstract
The present investigation on the effect of IBA and cutting thickness on growth of grape rootstocks on days required for sprouting, sprouting percentage (%), number of sprouted bud per cuttings, Length of shoots 30,60,90,120 (cm) days after planting, Number of leaves per cutting, leaf area (cm2), fresh weight of shoots (g), dry weight of shoots (g), root: shoot on a fresh weight basis, root: shoot on a length basis, Root: shoot on dry weight basis, survival percentage (%) under protected condition was carried out during year 2020-2021. Factorial Random Block Design with three factors. 1st Factor four rootstock levels *viz.* Dogridge V_1, Paulsen V_2, 110R V_3 and Salt creek V_4. 2nd Factor three levels of cutting thickness *viz.* lower portion of cuttings L, middle portion of cuttings M and upper portion of cuttings U. 3rd factor three levels of IBA concentration IBA – control G_0, IBA-1000 ppm G_1 and IBA-2000 ppm G_2. Among all the treatments results it was observed that cutting thickness of lower and middle portion of cutting showed maximum growth parameters while IBA concentration of 1000 ppm and 2000 ppm showed maximum growth attribute for grape rootstocks.

Keywords: Grape rootstocks, Cutting thickness, IBA concentrations, Growth parameters

Introduction
Grape (*Vitis vinifera* L.) is one of the most delicious, refreshing fruit belonging to Family Vitaceae (2n = 2x = 38) is a commercially important fruit crop of India. It is a temperate region crop that has got acclimatized to the sub-tropical climate of peninsular India. Propagation practices play an important role in the establishment any fruit crop. It involves the formation and development of new individual plants, which are utilized in establishing new plantings. In general, plant propagation involves two different types of developmental life cycle *viz*. Sexual and Asexual (vegetative). In most fruit crops, better propagation results are often achieved with vegetative techniques. Grapes are generally propagated through vegetative means. For grafting; the rootstock should be tolerant or resistant to salinity, water, and phylloxera etc. Wedge Grafting is the most common method of grafting. Layering is of common use in difficult root types like *Muscadine* Spp. There is a positive effect of Indole Butyric Acid (IBA) and the portion of cane segment on rooting and cuttings of grapevine rootstock and Cabernet France (Vitis vinifera L.) under the condition of the hydroponic cultural system (Daskalakis *et al.* 2018). Propagation through cutting is a very common method for rootstock propagation. The exact information on growing rootstocks under different concentrations of IBA in the grape rootstock with use of different cutting portion is not available. If cuttings are propagated according to portion of cuttings, it will help to manage the wastage of nursery planting material as well as increase the availability of maximum planting material to the farmer. In recent year's propagation through Bench grafting in grape usually observed maximum wastage of rootstock material because of rootstock scion incompatibility at nursery condition. It will also helpful for jugging for proper cutting portion and IBA concentration will induce grape propagation.

Material and Methods
The experiment was carried out Instructional Cum Research Farm at Govt. College of Agriculture Osmanabad during month 5th January 2020 to 7th May 2021 on different grape rootstocks. Treatment was replicated thrice laid out Factorial Random Block Design (FRBD) with three factors contain 36 treatment. 1st factor, four rootstock levels *viz*. Dogridge, Paulsen, 110R and Salt Creek. 2nd factor, three levels of cutting thickness *viz.* lower portion of cuttings, middle portion of cuttings and upper portion of cuttings. 3rd factor, three levels of IBA concentration IBA - Control, IBA -1000 ppm and IBA -2000 ppm.

Cutting selected from authentic mother block of Maharashtra Rajya Draksha Bagaitdar Sangh (M.R.D.B.S), Ozar and its Telegoan research farm, Taluka - Dindori Dist. Nashik. After harvesting cuttings were separated according to their portion use for planting thick, medium and thin portion of cutting thickness. Cuttings were treated with 1% systematic fungicide solution then treated with IBA concentrations control, 1000 ppm and 2000 ppm solutions for 2-3 min. and planted out according to treatments in every replication in experimental plot.

Observation recorded: Observations were recorded at monthly interval up to 120 days.

Growth parameters

1. **Days required for sprouting:** The treated cuttings were observed daily under each treatment for its sprouting. The number of days required for the first sprouting was recorded.
2. **Sprouting percentage (%):** It was calculated by using this formula.

$$\text{Sprouting percentage (\%)} = \frac{\text{Total number of sprouted cuttings}}{\text{Total number of cuttings planted}} \times 100$$

3. **Number of sprouted buds per cutting:** Count number of sprouted buds per cutting after 30 days of planting of cuttings
4. **Length of shoots (cm):** The total length of the shoot per cutting in each treatment was recorded by measuring scale at 30, 60, 90, and 120 days.
5. **Number of leaves per cutting:** The number of leaves in each cutting on the 120th day after planting was recorded.
6. **Leaf area (cm^2):** The total leaf area in each cutting on 120th day after planting was measured by graphical method and expressed in centimeter square.
7. **Fresh weight of shoots (g):** The total fresh weight of the shoots per cutting was taken immediately after removal from the polybag in each treatment by destructive method. The weight was measured with the help of an electronic balance and expressed in grams on 120thday after planting
8. **Dry weight of shoots (g):** The total shoots of each sample of the treatment was collected and they are oven dried at a temperature of 55ºC and then the dry weight was recorded with the help of an electronic balance and expressed in grams on 120thday after planting.
9. **Root to shoot ratio on a fresh weight basis:** The root to shoot ratio was calculated from the weight of the roots to the weight of the shoot on a fresh matter basis and expressed in a ratio by using the following formulae.

$$\text{Root/ shoot ratio} = \frac{\text{Fresh matter weight of the root (g)}}{\text{Fresh matter weight of the shoot (g)}}$$

10. **Root to shoot ratio on a length basis:** The root to shoot ratio was calculated from the weight of the roots to the weight of the shoot on a length basis and expressed in a ratio by using the following formulae.

$$\text{Root/ shoot ratio} = \frac{\text{Length of the root (g)}}{\text{Length of the shoot (g)}}$$

11. **Root to shoot ratio on dry weight basis:** The root to shoot ratio was calculated from the weight of the roots to the weight of the shoot on a dry matter basis and expressed in the ratio by using the following formulae.

$$\text{Root/ shoot ratio} = \frac{\text{Dry matter weight of the root (g)}}{\text{Dry matter weight of the shoot (g)}}$$

12. **Survival Percentage (%):** The total number of rooted cuttings that survived under each treatment was recorded at the end of the experimental period and the survival percentage of rooted cuttings to that of diseased cuttings was calculated and expressed in percentage on 120th day after planting.

Results and Discussion

Days required for sprouting: Data depicted in Table no-1.The rootstock variety 110R V_3 had taken minimum mean days (20.83 days) for sprouting whereas, maximum in Paulsen V_2 (23.07 days), lower portion cutting had took minimum mean days (21.24 days) for sprouting whereas, maximum mean days (23.18 days) for sprouting was observed in upper portion of cuttings. Interaction effect of V_3U had required minimum mean days (18.58 days) for sprouting, however maximum mean days (26.48 days) for sprouting was noticed in interaction V_2U. Interaction effect of LG_1 required minimum mean days (19.80 days) whereas, maximum mean days (24.26 days was observed in interaction UG_1. From the above results it is clear that auxin promotes faster cell division and callusing, which helps to start physiological activities in plant parts and resulting in early sprouting of cuttings. It can be said that in the thicker cuttings there is more amount of carbohydrates which helped it to sprout early as camp aired to medium and upper portion cuttings. Similar results were reported by Ghosh *et al.* (2017) [2] in phalsa, Seiar (2017) [3] in pomegranate.

Number of sprouted bud per cuttings

Rootstock variety Dogridge V_1 had maximum mean sprouting percentage (74.04%) whereas, minimum mean sprouting percentage (67.47%) was recorded in the Salt creek V_4. The lower portion of cutting had maximum mean sprouting percentage (77.20%) however minimum mean sprouting percentage (64.16%) was observed in upper portion cuttings. The IBA concentrations 2000 ppm G_2 had maximum mean sprouting percentage (76.57%) whereas, minimum mean sprouting percentage (65.22%) was noticed in IBA control G_0. Interaction V_4L had observed maximum mean sprouting percentage (81.17%) whereas minimum mean sprouting percentage of cuttings (55.54%) was noticed in interaction V_4U. Interaction LG_2 had maximum mean sprouting percentage (84.28%) however minimum mean sprouting percentage (60.81%) was observed in interaction UG_0. From the above results, it was noticed that high accumulation of carbohydrates results in higher callus formation in the cuttings with an optimum dose of auxin resulting highest percentage of sprouted cuttings. Translocation of carbohydrates and accumulation of auxin inside of cuttings for completion of physiological process plays important role in the sprouting of cuttings. The early and increased sprouting might be due to the auxin which enhanced the hydrolysis of reserve food material and regulated the endogenous auxin level through enhancement of IBA oxidase activity. Similar results were recorded by, Seiar (2017) [3] and Eirini *et al.* (2014) [4] in pomegranate.

Table 1: Effect of rootstock variety cutting thickness and IBA concentration on growth parameters of grape rootstock and their interaction

Factor/Interaction	Days to sprout (d)	Sprouting percentage (%)	Sprouted bud per cuttings	Length of shoots 30 days (cm)	Length of shoots 60 days (cm)	Length of shoots 90 days (cm)	Length of shoots 120 days (cm)	leaves per cutting	Leaf area (cm^2)	Fresh weight (g)	Dry fresh weight(g)	Roots: shoot on fresh weight basis	Roots: shoot on dry weight basis	Roots: shoot on length basis	Survival (%)
V_1	22.81	74.04	1.26	2.03	5.10	9.56	13.99	11.41	18.75	4.30	1.31	0.44	0.81	0.42	53.30
V_2	23.07	70.57	1.44	1.66	5.97	10.83	16.03	13.19	18.01	5.28	1.30	0.62	0.86	0.64	58.04
V_3	20.83	72.94	1.36	2.07	5.72	10.41	15.60	16.59	22.49	6.64	1.47	0.41	0.84	0.57	55.56
V_4	21.43	67.47	1.33	1.89	3.78	9.23	14.83	13.79	23.88	6.00	1.25	0.48	0.98	0.47	53.57
SE ±	0.65	1.63	0.044	0.113	0.353	0.397	0.448	0.399	0.400	0.225	0.055	0.02	0.03	0.03	1.28
CD ± @5%	1.84	4.56	0.123	0.319	0.996	1.119	1.263	1.125	1.127	0.634	0.154	0.07	0.08	0.07	3.59
L	21.24	77.20	1.42	2.23	6.59	11.04	16.53	14.36	21.26	6.21	1.52	0.46	0.85	0.48	60.37
M	21.70	72.41	1.34	1.94	4.73	10.35	15.23	14.43	21.81	6.35	1.48	0.53	0.93	0.46	58.77
U	23.18	64.16	1.26	1.59	4.11	8.63	13.58	12.44	19.27	4.11	0.99	0.47	0.84	0.64	46.22
SE ±	0.56	1.41	0.038	0.098	0.305	0.346	0.388	0.345	0.346	0.195	0.048	0.02	0.03	0.02	1.11
CD ± @5%	1.59	3.90	0.11	0.276	0.863	0.972	1.094	0.97	0.976	0.549	0.136	0.06	0.07	0.06	3.11
G_0	22.24	65.22	1.08	1.70	4.53	9.23	13.67	10.98	19.26	3.98	1.21	0.45	0.89	0.48	44.78
G_1	21.90	71.97	1.43	2.10	5.65	10.40	15.45	15.03	22.30	6.94	1.38	0.47	0.91	0.55	59.63
G_2	21.97	76.57	1.52	1.96	5.25	10.39	16.22	15.22	20.79	5.76	1.42	0.53	0.82	0.54	60.95
SE ±	0.56	1.41	0.038	0.098	0.309	0.344	0.388	0.345	0.346	0.195	0.049	0.02	0.03	0.02	1.11
CD ± @5%	NS	3.95	0.106	0.28	0.869	0.969	1.09	0.97	0.976	0.549	0.143	0.06	0.08	0.06	3.11
AxB															
V_1L	22.51	78.33	1.47	2.31	5.60	9.58	13.97	13.67	19.38	6.01	1.71	0.31	0.87	0.40	62.37
V_1M	22.59	78.07	1.19	2.16	4.67	9.40	13.56	11.31	18.09	4.09	1.37	0.56	0.86	0.36	56.79
V_1U	23.34	65.72	1.12	1.70	5.03	9.70	14.43	9.24	18.78	2.81	0.85	0.44	0.69	0.50	40.74
V_2L	19.78	75.17	1.48	2.06	7.84	13.10	18.82	11.76	18.03	5.84	1.46	0.71	0.82	0.55	62.10
V_2M	22.95	71.58	1.50	1.54	5.54	10.72	16.57	15.09	18.69	6.18	1.40	0.62	0.89	0.66	63.46
V_2U	26.48	64.96	1.34	1.38	4.52	8.65	12.71	12.71	17.32	3.82	1.04	0.53	0.87	0.71	48.57
V_3L	22.57	74.12	1.39	2.28	6.52	11.32	16.31	17.03	21.79	6.49	1.65	0.30	0.80	0.51	56.79
V_3M	21.35	74.29	1.33	2.08	5.52	10.74	15.69	17.43	24.64	7.76	1.73	0.41	0.89	0.40	56.17
V_3U	18.58	70.41	1.28	1.87	5.11	9.16	14.81	15.30	21.03	5.69	1.03	0.50	0.85	0.82	53.73
V_4L	20.08	81.17	1.36	2.26	6.39	10.16	17.02	14.98	28.06	6.51	1.27	0.50	0.92	0.47	60.21
V_4M	19.90	65.72	1.33	2.00	3.18	10.53	15.10	13.88	23.62	7.38	1.43	0.53	1.07	0.42	58.64
V_4U	24.32	55.54	1.31	1.41	1.78	7.00	12.36	12.51	19.96	4.11	1.05	0.40	0.95	0.52	41.85
SE ±	1.13	2.83	0.075	0.196	0.612	0.687	0.776	0.691	0.692	0.390	0.095	0.04	0.05	0.04	2.20
CD ± @5%	3.18	7.91	NS	NS	1.73	1.94	2.19	1.95	1.95	1.099	0.267	0.12	NS	0.12	6.41
BxC															
LG_0	23.30	70.21	1.05	1.98	5.32	9.90	14.27	10.68	18.43	3.59	1.12	0.50	0.94	0.53	44.79

LG_1	19.80	77.09	1.51	2.54	8.03	11.67	16.72	15.78	24.68	7.57	1.74	0.42	0.88	0.46	67.22
LG_2	20.62	84.28	1.71	2.16	6.42	11.55	18.61	16.62	22.33	7.48	1.71	0.46	0.74	0.45	69.09
MG_0	21.68	64.64	1.08	1.72	4.02	8.79	13.12	11.57	20.83	4.70	1.37	0.45	0.92	0.39	51.44
MG_1	21.65	71.37	1.43	2.11	5.23	11.53	16.50	15.46	21.72	8.67	1.48	0.51	0.90	0.48	60.19
MG_2	21.76	81.24	1.52	2.01	4.93	10.73	16.07	16.26	21.24	5.68	1.61	0.64	0.96	0.52	64.68
UG_0	21.75	60.81	1.11	1.41	4.27	9.00	13.63	10.70	18.53	3.64	1.14	0.42	0.81	0.53	38.11
UG_1	24.26	67.46	1.35	1.66	3.68	8.01	13.13	13.83	20.49	4.58	0.91	0.52	0.95	0.72	51.48
UG_2	23.52	64.20	1.33	1.70	4.39	8.88	13.98	12.79	18.80	4.10	0.94	0.48	0.76	0.67	49.08
S.E (m) ±	0.977	2.45	0.065	0.169	0.530	0.595	0.672	0.598	0.599	0.337	0.082	0.04	0.04	0.04	1.93
CD @ 5%	2.75	6.85	0.184	NS	1.494	1.679	1.895	1.687	1.690	0.952	0.232	0.10	0.12	0.11	5.38
AxC															
V_1G_0	23.37	67.22	1.04	1.49	4.66	8.91	12.66	8.96	16.78	3.67	1.03	0.41	0.81	0.43	45.09
V_1G_1	22.73	76.21	1.33	2.24	5.11	9.35	13.18	11.87	21.09	5.51	1.57	0.37	0.88	0.39	55.56
V_1G_2	22.34	78.69	1.40	2.43	5.53	10.42	16.12	13.40	18.38	3.73	1.33	0.73	0.73	0.43	59.26
V_2G_0	22.26	67.12	1.18	1.54	5.50	10.04	14.47	10.42	16.98	3.04	1.14	0.52	0.87	0.63	43.27
V_2G_1	23.81	70.27	1.56	1.79	6.32	11.07	16.47	14.13	19.96	6.22	1.29	0.60	0.88	0.64	69.32
V_2G_2	23.16	74.31	1.59	1.64	6.09	11.36	17.17	15.00	17.11	6.58	1.47	0.52	0.83	0.66	61.54
V_3G_0	21.57	66.64	1.02	1.72	4.63	9.77	14.31	13.66	19.92	5.24	1.35	0.30	0.81	0.47	48.85
V_3G_1	19.99	72.01	1.36	2.43	6.07	10.98	16.21	18.90	21.49	9.00	1.34	0.44	0.98	0.69	56.54
V_3G_2	20.93	80.17	1.62	2.07	6.44	10.47	16.29	17.21	26.06	5.69	1.72	0.47	0.75	0.56	61.30
V_4G_0	21.78	59.90	1.07	2.04	3.34	8.20	13.24	10.89	23.36	3.96	1.31	0.37	0.89	0.39	41.90
V_4G_1	21.08	69.40	1.47	1.94	5.08	10.20	15.94	15.20	26.66	7.02	1.30	0.47	1.07	0.49	57.10
V_4G_2	21.44	73.12	1.47	1.68	2.92	9.29	15.29	15.28	21.62	7.02	1.14	0.59	0.97	0.54	61.70
S.E (m) ±	1.13	2.83	0.075	0.196	0.612	0.687	0.776	0.691	0.692	0.390	0.098	0.04	0.05	0.04	2.22
CD @ 5%	N.S	NS	N.S	0.551	NS	NS	NS	NS	1.95	1.098	NS	0.12	0.14	NS	6.21
AxBxC															
V_1LG_0	24.50	68.32	1.07	1.73	4.37	8.07	12.33	9.13	16.27	4.70	1.10	0.28	0.80	0.57	44.52
V_1LG_1	20.73	79.63	1.53	2.87	6.87	10.67	13.50	14.87	23.33	8.33	2.30	0.30	0.96	0.35	66.67
V_1LG_2	22.30	87.03	1.80	2.33	5.57	10.00	16.07	17.00	18.53	5.00	1.73	0.35	0.85	0.27	75.93
V_1MG_0	23.97	70.37	0.97	1.47	3.60	8.53	11.57	9.53	17.00	4.07	1.20	0.39	0.88	0.34	53.70
V_1MG_1	23.82	79.59	1.27	2.27	5.00	9.71	13.63	11.53	19.07	5.07	1.57	0.47	0.82	0.31	59.26
V_1MG_2	19.98	84.24	1.33	2.73	5.40	9.97	15.47	12.87	18.20	3.13	1.33	0.81	0.87	0.42	57.41
V_1UG_0	21.65	62.96	1.10	1.27	6.00	10.13	14.07	8.20	17.07	2.23	0.80	0.57	0.75	0.39	37.04
V_1UG_1	23.63	69.41	1.20	1.60	3.47	7.67	12.40	9.20	20.87	3.13	0.84	0.35	0.85	0.52	40.74
V_1UG_2	24.73	64.80	1.07	2.23	5.63	11.30	16.83	10.33	18.40	3.07	0.92	0.40	0.47	0.60	44.44
V_2LG_0	21.58	70.37	1.10	1.93	7.37	13.13	16.93	8.67	16.90	2.47	0.98	0.55	0.91	0.57	40.00
V_2LG_1	18.27	74.22	1.63	2.27	7.90	12.32	17.63	12.80	18.40	7.00	1.41	0.96	0.79	0.55	74.07
V_2LG_2	19.50	80.91	1.70	1.97	8.27	13.86	21.90	13.81	18.80	8.07	2.00	0.62	0.75	0.53	72.22

V_2MG_0	22.42	68.83	1.27	1.37	4.33	8.07	13.33	11.40	16.37	4.07	1.40	0.73	0.96	0.55	50.19
V_2MG_1	22.60	64.43	1.43	1.73	6.73	12.73	19.50	16.20	21.67	8.13	1.53	0.73	0.89	0.61	72.22
V_2MG_2	23.83	81.48	1.80	1.53	5.57	11.37	16.87	17.67	18.03	6.33	1.27	0.39	0.82	0.82	67.96
V_2UG_0	22.77	62.17	1.17	1.33	4.80	8.93	13.13	11.20	17.67	2.60	1.03	0.49	0.75	0.75	39.61
V_2UG_1	30.55	72.17	1.60	1.37	4.33	8.16	12.27	13.40	19.80	3.53	0.93	0.53	0.97	0.76	61.67
V_2UG_2	26.13	60.54	1.27	1.43	4.43	8.87	12.73	13.53	14.50	5.33	1.15	0.57	0.91	0.61	44.44
V_3LG_0	24.97	66.67	1.03	2.50	4.40	10.27	13.27	14.40	18.70	4.60	1.41	0.33	0.89	0.47	46.29
V_3LG_1	21.17	73.32	1.40	2.50	8.77	13.55	18.60	20.30	20.97	9.47	1.90	0.24	0.89	0.44	64.82
V_3LG_2	21.57	82.39	1.73	1.47	6.40	10.13	17.07	16.40	25.70	5.40	1.63	0.36	0.63	0.61	59.26
V_3MG_0	21.27	67.17	1.00	2.73	4.40	8.83	13.70	14.40	21.77	4.67	1.37	0.32	0.87	0.33	59.26
V_3MG_1	20.55	71.65	1.40	2.03	5.12	10.33	15.63	18.00	23.53	10.80	1.13	0.36	0.98	0.57	48.15
V_3MG_2	22.23	84.05	1.60	1.87	7.03	13.07	17.73	19.90	28.63	7.80	2.70	0.57	0.81	0.31	61.11
V_3UG_0	18.48	66.09	1.03	2.07	5.10	10.20	15.97	12.17	19.30	6.47	1.27	0.26	0.66	0.63	41.00
V_3UG_1	18.25	71.07	1.27	1.67	4.33	9.07	14.40	18.40	19.97	6.73	1.00	0.73	1.07	1.07	56.67
V_3UG_2	19.00	74.08	1.53	2.50	5.90	8.20	14.07	15.33	23.83	3.87	0.83	0.49	0.80	0.75	63.52
V_4LG_0	22.13	75.50	1.00	2.40	5.13	8.13	14.53	10.50	21.83	5.47	0.99	0.42	0.87	0.51	48.33
V_4LG_1	19.02	81.21	1.47	2.53	8.60	10.13	17.13	15.17	36.03	11.47	1.37	0.59	1.16	0.52	63.33
V_4LG_2	19.10	86.79	1.60	1.83	5.43	12.20	19.40	19.27	26.30	6.00	1.47	0.50	0.73	0.39	68.96
V_4MG_0	19.08	52.19	1.07	2.57	3.73	9.73	13.87	10.93	28.17	10.67	1.50	0.34	0.97	0.33	42.59
V_4MG_1	19.62	69.80	1.60	1.70	4.07	13.33	17.23	16.10	22.60	5.47	1.67	0.43	0.91	0.41	61.11
V_4MG_2	21.00	75.17	1.33	1.73	1.73	8.53	14.20	14.60	20.10	3.27	1.13	0.80	1.33	0.51	72.22
V_4UG_0	24.12	52.00	1.13	1.17	1.17	6.73	11.33	11.23	20.07	4.93	1.45	0.35	0.91	0.34	34.78
V_4UG_1	24.62	57.20	1.33	1.60	2.57	7.13	13.47	14.33	21.33	4.13	0.87	0.38	0.87	0.53	46.85
V_4UG_2	24.22	57.41	1.47	1.47	1.60	7.13	12.27	11.97	18.47	5.47	0.84	0.47	1.07	0.70	43.93
S.E (m) ±	1.95	4.90	0.13	0.339	1.060	1.190	0.339	1.20	1.20	0.675	0.16	0.07	0.09	0.08	3.85
CD @ 5%	N.S	NS	N.S	N.S	N.S	3.357	N.S	NS	3.381	1.90	0.463	0.20	0.25	0.21	10.76

Sprouted bud per cutting

The rootstock variety Paulsen (V2) had maximum mean number of sprouted bud per cutting (1.44) whereas minimum mean sprouted bud per cutting (1.26) was observed in Dogridge V_1. Lower portion cutting had maximum mean sprouted bud per cutting (1.42) however minimum mean sprouted bud per cutting (1.26) was observed in upper portion of cuttings. The concentration of IBA 2000 ppm G_2 had maximum mean sprouted bud per cutting (1.52) however minimum mean sprouted bud per cutting (1.08) was noticed in IBA control G_0. Interaction LG_2 had observed maximum mean sprouted bud per cutting (1.71) whereas minimum mean sprouted bud per cutting (1.05) was noticed in interaction LG_0. Plant growth regulators attributed to increased cell division and elongation at higher IBA concentration with favorable climatic conditions and this is possible reasons for increase activation of growth parameters which probably increases the number of sprouted buds per cutting. Similar results were found by, Shukla *et al.* (2010) [5] in peach, Seiar (2017) [3] in pomegranate and, Rolaniya *et al.* (2018) [6] in grapes.

Shoot length

Length of shoot 30 days after planting of cuttings (cm)

The rootstock variety 110R V_3 had maximum mean length of the shoot (2.07 cm) however the minimum mean length of the shoot (1.66 cm) which was observed in Paulsen V_2. The lower portion of cutting had maximum mean length of the shoot (2.23 cm) however minimum mean length of the shoot (1.59 cm) was noticed in upper portion cuttings. The IBA concentration of 1000 ppm G_1 had maximum mean length of the shoot (2.10 cm) whereas minimum mean length of the shoot (1.70 cm) was noticed in IBA control G_0. Interaction V_1G_2 had observed maximum mean length of the shoot (2.43 cm) however minimum mean length of the shoot (1.49 cm) was noticed in interaction V_1G_0. It is clear from the above results that for increases in the length of shoot, application of the auxin like IBA might have a positive impact on growth stimulation. At high auxin concentration, it might have an inhibitory effect on the growth of bud. The effect can be caused due to apical dominance. Auxin helps to promote cell division and cell elongation and favors start hydrolysis of carbohydrates and promotes early bud break. Accumulation of nitrogen from root to shoot results in shoots growth of the plant. Similar results were also reported by, Singh *et al.* (2015) [7] in Phalsa, Seair *et al.* (2017) [3] and, Eirini *et al.* (2014) [4] in pomegranate.

Length of shoot 60 days after planting of cuttings (cm)

The rootstock variety Paulsen V_2 had maximum mean length of the shoot (5.97 cm) whereas minimum mean length of the shoot (3.78 cm) which was observed on the Salt Creek V_4. Lower portion of cuttings had the maximum mean length of the shoot (6.59cm) however minimum mean length of the shoot (4.11 cm) was noted in upper portion of cuttings. The IBA concentration of 1000 ppm G_1 had maximum mean length of the shoot (5.65cm) whereas minimum mean longest length of shoot (4.53 cm) was noticed in IBA control G_0. Interaction V_2L which had observed maximum mean length of the shoot (7.84 cm) whereas minimum mean length of the shoot (1.78 cm) was noticed in interaction V_4U. Interaction LG1 had observed maximum mean length of the shoot (8.03cm) however minimum mean length of the shoot (2.92 cm) was noticed in interaction V_4G_2. From above results it was clear that application of the auxin like IBA might have a positive impact on growth stimulation. The high auxin concentration, leads an inhibitory effect on the growth of bud. The effect can be caused due to apical dominance. Auxin helps to promote cell division and cell elongation and favors start hydrolysis of carbohydrates and promotes early bud break. Accumulation of nitrogen from root to shoot results in shoots growth of the plant. Similar results were also reported by, Singh *et al.* (2015) [7] in Phalsa, Seair *et al.* (2017) [3] and Eirini *et al.* (2014) [4] in pomegranate, Shirzad *et al.* (2011) [8] in Fig.

Length of shoot 90 days after planting of cuttings (cm)

The rootstock variety Paulsen V_2 had maximum mean length of the shoot (10.83 cm) however minimum mean length of the shoot after 90 days of planting (9.23 cm) was observed on rootstock Salt Creek V_4. Lower portion of cutting had maximum mean length of the shoot (11.04 cm) whereas minimum mean length of the shoot (8.63cm) was observed in upper portion of cuttings thickness. The IBA concentration of 1000 ppm i.e. G_1 had maximum mean length of the shoot (10.40 cm) whereas minimum mean length of the shoot (9.23 cm) was noticed in IBA G_0. Interaction V_2L had observed maximum mean length of the shoot (13.10 cm) however minimum mean length of the shoot (7.0 cm) was noticed in interaction V_4U. Interaction LG_1 had observed maximum mean length of the shoot (11.67 cm) whereas the minimum mean length of the shoot (8.01 cm) was noticed in interaction UG_1. Interaction V_2LG_2 had observed maximum mean length of the shoot (13.86 cm) however the minimum mean length of the shoot (7.13 cm) was observed in interaction V_4UG_1. Auxin helps to promote cell division and cell elongation and favors start of hydrolysis of carbohydrates and promotes early bud break. Accumulation of nitrogen from root to shoot results in shoots growth of the plant. Similar results were also reported by, Singh *et al.* (2015) [7] in Phalsa, Seair *et al.* (2017) [3] and Eirini *et al.* (2014) [4] in pomegranate.

Length of shoot 120 days after planting of cuttings (cm)

The rootstock variety Paulsen V_2 had maximum mean length of the shoot (16.03 cm) whereas minimum mean length of the shoot (13.99 cm) was observed in rootstock variety Dogridge V_1. The lower portion cutting had maximum mean length of the shoot (16.53 cm) however the minimum mean length of the shoot (13.58 cm) after 120 days of planting was noticed in upper portion of cuttings. The IBA concentrations 2000 ppm G_2 had maximum mean length of the shoot (16.22 cm) whereas minimum mean length of the shoot (13.67cm) had noticed in IBA control (G_0). Interaction V_2L had observed a maximum mean length of the shoot (18.82 cm) however minimum mean length of the shoot (12.36 cm) was noticed interaction V_4U after 120 days of planting. Interaction LG_2 had observed maximum mean length of the shoot (18.61 cm) however the minimum mean length of the shoot (13.12 cm) was noticed in interaction MG_0 after 120 days of planting. It is clear from the above results that for increases in the length of shoot, application of the auxin like IBA might have a positive impact on growth stimulation. At high auxin concentration, it might have an inhibitory effect on the growth of bud. The effect can be caused due to apical dominance. Auxin helps to promote cell division and cell elongation and favors start of hydrolysis of carbohydrates and promotes early bud break. Accumulation of nitrogen from root to shoot results in shoots growth of the plant. Similar results were also reported by, Singh *et al.* (2015) [7] in Phalsa, Seair *et al.* (2017) [3], Eirini *et al.* (2014) [4] in pomegranate, Shirzad *et al.* (2011) [8] in Fig.

Number of leaves per cuttings

The rootstock variety 110R V_3 had maximum mean number of leaves per cuttings (16.59) whereas minimum number of leaves (11.41) was noticed in Dogridge V_1. The middle portion of cuttings had maximum mean number of leaves (14.43) however minimum mean number of leaves (12.44) was observed in upper of portion cuttings. The IBA concentration 2000 ppm G_2 produced maximum mean number of leaves (15.22) however the minimum number of leaves (10.89) was observed in IBA G_0. Interaction V_3M had observed the maximum mean number of leaves (17.43) whereas minimum mean number of leaves per cuttings (9.24) was noticed in interaction V_1U. Interaction LG_2 had maximum mean number of leaves (16.62) however the minimum mean number of leaves per cuttings (10.70) was observed in interaction UG_0. Auxin regulates various aspects of plant growth and development by affecting numerous processes including cell division, cell enlargement, and differentiation. Favorable climatic conditions play an important role to increase the number of leaves. The treatment of IBA resulted more number of leaves per cuttings is associated with the number of sprouts as well as the length of sprouts of cutting. This in turn depends on hydrolysis of reserve food materials, proper shoot and root balance. Similar results were also observed by, Kumar *et al.* (2015) in citrus, Ghosh *et al.* (2017) [2] in Phalsa, Shukla *et al.* (2010) [5] in peach.

Leaf area (cm^2)

The rootstock variety Salt Creek V_4 had maximum mean leaf area of rootstock cutting (23.88 cm2) whereas minimum mean leaf area (18.1 cm^2) was noticed on Paulsen V_2. The middle portion cutting had maximum mean rooting diameter (21.81 cm^2) however, minimum mean leaf area (19.27 cm^2) was noted in upper cuttings.

The concentration of IBA 1000 ppm G_1 had maximum mean leaf area (22.30 cm^2) however minimum mean leaf area (19.26 cm^2) was noticed in IBA G_0. Interaction V_4L had recorded maximum mean leaf area (28.06 cm^2) whereas, minimum mean leaf area (17.32 cm^2) was recorded in interaction V_2U. Interaction LG_1 had maximum mean leaf area (24.68 cm^2) however minimum mean leaf area (18.43 cm^2) was observed in interaction LG_0. Interaction V_4G_1 had recorded maximum mean leaf area (26.66 cm^2) however minimum mean leaf area (16.78 cm^2) was noticed in interaction V_1G_0.

Interaction V_4LG_1 had observed maximum mean leaf area (36.03 cm^2) however minimum mean leaf area (16.37 cm^2) was observed in interaction V_1LG_0. The relative humidity and optimum light intensity which are the important factors in the development of leaf coupled with auxin content activated the synthesis of more carbohydrates in the leaves which might have resulted in elongation of leaves through cell division and cell elongation which resulted in more leaf area per cutting when compared to all other treatments. Similar results were undertaken by, Ghosh *et al.* (2017) [2] in phalsa, Patil *et al.* (2001) and Abhinav *et al.* (2016) [10] in grape.

Fresh weight of shoot (g)

The rootstock variety 110R V_3 had maximum mean fresh weight of shoot (6.64 g) whereas minimum mean fresh weight of shoot (4.30 g) which was observed in Dogridge (V_1). The middle portion cutting had maximum mean fresh weight of shoot (6.35 g) however the minimum mean fresh weight of shoot (4.11 g) was noticed in upper portion of cuttings. Interaction V_3M had observed maximum dry weight of shoot (7.76 g) however minimum mean fresh weight of shoot (2.81 g) was observed noted in interaction V_1U. Interaction MG_1 had observed maximum fresh weight of shoot (8.67 g) whereas minimum mean fresh weight of shoot (3.59 g) was noticed in interaction LG_0. Interaction V_3G_1 had observed maximum mean fresh weight of shoot (9.00 g) however minimum mean fresh weight of shoot (3.04 g) was observed in interaction V_2G_0. Interaction V_4LG_1 had maximum fresh weight of shoot (11.47g) minimum mean fresh weight of shoot (2.47 g) was observed in interaction V_2LG_0. It is clear from above results that auxins plays important role to start early plant activity. Cuttings produced more sprouts, leaves, increased leaf area, leaf chlorophyll content, more starch, total sugar, and C: N ratio which resulted in maximum fresh weights of the shoot. Similar results were also reported by Seiar (2017) [3] in pomegranate, H. Rymbai *et al.* (2010) [9] in guava, Ghosh *et al.* (2017) [2] in phalsa, Shriram *et al.* (2021) in grapes.

Dry weight of shoot (g)

The rootstock variety 110 (V_3) had maximum mean dry weight of shoot (1.47 g) whereas minimum mean dry weight of shoot (1.25 g) was observed in the Salt Creek (V_4). The lower portion of cutting had maximum mean dry weight of shoot (1.52 g) however minimum mean dry weight of shoot (0.99 g) was noticed in upper portion cuttings. The concentration of IBA 2000 ppm G_2 had maximum mean dry weight of shoot (1.42 g) whereas, minimum mean dry weight of shoot (1.21 g) was noticed in control G_0. Interaction V_3U had observed maximum dry weight of shoot (1.03 g) minimum mean dry weight of shoot (1.05 g) was observed in interaction V_4U. Interaction LG_1 had observed maximum mean dry weight of shoot (1.74 g) however minimum dry weight of shoot (1.37 g) was noticed in interaction MG_0. Interaction V_3UG_1 had noticed maximum dry weight of shoot (1.00 g) whereas, minimum mean dry weight of shoot (0.80 g) was observed in interaction V_1UG_0. Application of IBA produced more number of leaves, increase shoot length, leaf chlorophyll content, C: N ratio, total starch, and sugar it might have results high cell division and elongation results in high dry weight of shoot. The study may attribute to the fact that optimum concentration of auxin, when applied may encourage the movement of natural auxin and other nutrients in the upward direction from roots and other parts which result in accumulation at the place of incision on the dry weight shoot. Similar results were undertaken by Rymbai *et al.* (2010) [9] in Guava, Seair (2017) [3] in Pomegranate, Singh *et al.* (2015) [7] in phalsa.

Root: shoot on a fresh weight basis

The rootstock variety Paulsen V_2 had maximum mean root: shoot on fresh weight basis (0.62) whereas, minimum mean root: shoot on fresh weight basis (0.44) was observed in Dogridge V_1. The middle portion cutting had maximum mean root: shoot on fresh weight basis (0.53) whereas, the minimum mean root: shoot on a fresh weight basis (0.47) was noticed in upper portion of cuttings. The IBA concentrations 2000 G_2 had maximum mean root: shoot on fresh weight basis (0.53) whereas, minimum mean root: shoot on fresh weight basis (0.45) was noticed in IBA control G_0. Interaction V_2L had observed maximum mean root: shoot on fresh weight basis (0.71) whereas, minimum mean root: shoot on fresh weight basis (0.30) was observed in interaction V_3L. Interaction MG_2 had observed maximum mean root: shoot on fresh weight basis (0.64) whereas, minimum mean root: shoot on fresh weight basis (0.42) was noticed in interaction (UG_0). Interaction V_1G_2 had observed maximum mean root: shoot on a fresh weight basis (0.73) minimum mean root: shoot on a fresh weight basis (0.30) was noticed in interaction V_3G_0. Interaction V_2LG_1 had observed maximum mean root: shoot on fresh weight basis (0.96). Whereas, minimum mean root: shoot on fresh weight basis (0.24) was noticed in interaction V_3LG_1.The above results clearly showed that, cutting thickness responsible for the produced number of sprout leaves increase in leaf area, leaf chlorophyll content more starch, total sugar, and C: N ratio which results in maximum root: shoot on a fresh weight basis. Similar results were undertaken by, Ghosh *et al*. (2017) [2] in pomegranate, Singh *et al.* (2015) [7] in phalsa, Seiar *et al.* in (2017) [3] in pomegranate, Rymbai *et al.* (2010) [9] in guava.

Root: shoot on a length basis

The rootstock variety Salt Creek V_4 had maximum mean root: shoot on length basis (0.98) However, minimum mean root: shoot on length basis (0.81) was observed in rootstock variety Dogridge V_1. The middle portion cuttings had maximum mean root: shoot on length basis (0.93) whereas, minimum mean root: shoot ratio on length basis (0.84) was observed in upper portion cuttings. The IBA concentration 1000 ppm G_1 had maximum mean root: shoot on length basis (0.91) whereas minimum mean root: shoot ratio on length basis (0.82) was noticed in IBA 2000 G_2. Interaction MG_2 had observed maximum mean root: shoot on length basis (0.96), followed by UG_1 (0.95) minimum mean root: shoot ratio on length basis (0.74) was observed in interaction LG_2. Interaction V_4G_1 had observed maximum mean root: shoot on length basis (1.07) whereas, minimum mean root: shoot on length basis (0.73) was observed in interaction V_1G_2. Interaction V_4MG_2 which had observed maximum mean root: shoot on fresh weight basis (1.33) minimum mean root: shoot on fresh weight basis (0.47) was observed in interaction V_1UG_2. The above results reviled that cutting thickness responsible for the produced number of sprout leaves increase in leaf area, leaf chlorophyll content more starch, total sugar, and C: N ratio which results from the maximum root and shoot ratio on a fresh weight basis.

Similar results were undertaken by, Ghosh *et al.* (2017) [2] in pomegranate, Singh *et al.* (2015) [7] in phalsa, Seiar *et al.* in (2017) [3] in pomegranate, Rymbai *et al.* (2010) [9] in guava.

Root: shoot on dry weight basis

The rootstock variety Paulsen V_2 had the maximum mean root: shoot on dry weight basis (0.48) However, minimum mean root: shoot on dry weight basis (0.42) was observed in Dogridge V_1. The upper portion of cutting had maximum mean root: shoot on a dry weight basis (0.64) whereas, the minimum mean root: shoot on dry weight basis (0.46) was observed on middle portion cuttings. The concentrations of IBA 1000 ppm G_1 had maximum mean root: shoot ratio on a dry weight basis (0.55) whereas, minimum mean root: shoot on fresh weight basis (0.48) was noticed in IBA control G_0. Interaction V3U had observed maximum mean root: shoot on dry weight basis (0.82) whereas, minimum mean root: shoot on dry weight basis (0.36) was observed in interaction V_1M. Interaction UG_1 had observed Maximum mean root: shoot on a dry weight basis (0.72) Whereas, minimum mean root: shoot on dry weight basis (0.39) was noticed in interaction MG_0. Interaction V_3UG_1 had observed maximum mean root: shoot on a dry weight basis (1.07) whereas, minimum mean root: shoot on a fresh weight basis (0.27) was observed in interaction V_1LG_2. The above results states that, cutting thickness is responsible for the production of number of sprouted leaves which turns increase in leaf area, leaf chlorophyll content starch, total sugar, and C: N which results, increasing the maximum root and shoot ratio on a fresh weight basis. Similar results were undertaken by, Ghosh *et al.* (2017) [2] in pomegranate, Singh *et al.* (2015) [7] in phalsa, Seiar *et al.* in (2017) [3] in pomegranate, Rymbai *et al.* (2010) [9] in guava.

Survival Percentage %

The rootstock variety Paulsen V_2 had maximum mean survival percentage (58.04%) whereas, minimum mean survival percentage (53.30%) was noticed in Dogridge V_1. The lower portion cutting had maximum mean survival percentage (60.37%) whereas, minimum mean survival percentage (46.22%) was observed in upper portion of cuttings. The concentration of IBA 2000 ppm G_2 had maximum mean survival percentage (60.95%) whereas, minimum mean survival percentage (44.78%) was observed in IBA G_0. Interaction V_2M had observed maximum mean survival percentage (63.46%) whereas, minimum mean survival percentage (40.74%) was observed on interaction V_1U. Interaction LG_2 showed maximum mean survival percentage (69.09%) However, the minimum mean survival percentage (44.79%) was noticed in interaction LG_0. Interaction V_2G_1 had maximum mean survival percentage (69.32%) However, the minimum mean survival percentage (41.90%) was observed in interaction V_4G_0. Interaction V_1LG_2 had maximum mean survival percentage (75.93) whereas minimum survival percentage (34.78%) was noticed in interaction V_4UG_0. From above results it was cleared that IBA treated cuttings showed a higher survival percentage than control. The superiority of IBA treated cuttings related to survival percentage under control condition is better. Lower and middle cuttings might have been facilitated root growth with better absorption of nutrients and moisture from soil because the higher number of healthy roots resulted in a good survival percentage. Similar results were recorded by, Shukla *et al.* (2010) [5] in peach. Singh *et al.* (2015) [7] in phalsa, Ghosh *et al.* (2017) [2] in phalsa, Abhinav *et al.* (2016) [10] in grape, Damer *et al.* (2014) [11] in pomegranate.

Conclusion

The results and discussion of the present experiment showed that, the effect of rootstock variety, cutting thickness and IBA concentrations levels produced significant influence on growth of grape rootstocks. From the critical evaluation of results of the present investigation, the following conclusions can be drawn as,

Lower cutting portion of cuttings had maximum growth parameters when treated with IBA 1000 ppm concentration for rootstock variety. Middle portion of cuttings had maximum growth attribute when treated with IBA 2000 ppm concentration for rootstock variety. Upper portion of cuttings had maximum growth attribute when treated with IBA 2000 ppm concentration for rootstock variety.

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